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Agricultural Research

Pulling the Plug

Story on page 6.

Toward a New Science of Trees

Historically, two things helped transform medical practitioners from barbers, bleeders, and mountebanks into educated and ethical professionals. First, they began to define their terms with precision, enabling physicians to teach others what they had learned and to build a body of scientific knowledge. Second, they laid aside old wives' tales and superstition and let the human body become their teacher—cadavers and live bodies, healthy bodies and diseased ones.

In many ways, I'm afraid, the science and art of treating tree damage and disease is about where medicine was when doctors used leeches. We need to follow the lead of modern medical science and get our terms defined and improve our basic understanding of tree biology.

Part of our trouble lies in treating trees as if they were human beings. Here again, lack of precise terms misleads us. Fertilizers, for example, are misnamed "tree food." If a tree is stressed or injured, dishing up more fertilizer, like chicken soup for sick people, is usually the first treatment proposed.

But trees are not people. While fertilizers provide elements that could help a tree growing in mineral-poor soil, they are definitely not tree food. Food is a substance that provides energy to power the biological process.

The real food for trees is carbohydrate, made by chlorophyll. When fertilizers are provided for a tree with low energy reserves, the elements in the fertilizer tie up the already low amounts of carbohydrate to form more tissue. As a result, the addition of so-called "tree food" can weaken a tree's defense system—or starve it to death.

We also run into confusion when we speak of *healing* a sick or wounded tree. To heal in human terms means to restore injured or infected tissues to their original state of health. But trees are unable to restore injured tissue. Once wood tissues are formed, they are locked in place. A tree is a *generating* organism, and all new cells are produced in new spatial positions. Human beings, on the other hand, are *regenerating* organisms in which cells and parts of cells are always being restored in their original positions. If you live to age 70, this regenerative process is carried out more than 270 billion times. Trees cannot do it even once!

The idea of healing a tree as if it were a wounded animal can lead us to make serious mistakes. The formation of callus, for example, has been considered a measure of healing in trees. To stimulate callus formation, branches are often pruned as close as possible to the joining stem—a type of amputation known as a flush cut. Now we know that flush cuts remove the defense boundary at the base of branches and can lead to no fewer than 14 serious problems.

The proper place to make a pruning cut is as close as possible to the swollen collar at the base of a branch. But the collars should not be removed—ever.

We also confuse treating a wound on a tree with treating human wounds. Our mothers used to paint a finger with Mercurochrome and cover it with a plastic bandage, as much for psychological reasons as any other. By the same token, if our tree gets wounded, we feel better if we paint it with a wound dressing.

But while Mercurochrome didn't actually harm us, many wound dressings can do serious harm to trees, especially those materials usually used for treating wood products. Further, there is no evidence at all to show that wound dressings stop rot. If dressings are so beneficial, why so many cavities in old treated wounds?

We also mix up treatment of decay in trees with treatment of tooth decay. Dentists grind out the decayed matter, sterilize the tissue, and fill the hole. The wellmeaning tree "dentist" does the same for a tree cavity; he digs out the decayed wood deep into sound wood, sterilizes the wood, and fills the hole.

Unlike people, however, the reason that trees have cavities after wounding is because the tree defense system is centered on forming walls or boundaries about the injured wood to ward off pathogens. Boundary formation is the tree's way of defending itself after injury—a process called compartmentalization. Then the tree proceeds to generate new cells in new positions. All that human intervention does when "treating" a cavity is to destroy a tree's defense systems.

Many fine tree professionals in the tree care industries understand this and are making needed changes in tree care practices. But it will take a long time to undo centuries of confusion. Step one must be to clarify our terms and to help educate people about trees by explaining in plain English how trees grow, defend themselves, and eventually die.

Alex Shigo, former chief scientist for USDA's Forest Service, presented the 1986 B.Y. Morrison Memorial Lecture, sponsored by Agricultural Research Service. Now the head of Shigo and Trees, Associates, in Durham, NH, he recently wrote and published two works, A New Tree Biology and A New Tree Biology Dictionary.

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Cover: Waist deep in a northern California waterway, Robert Pine, a technician with the Agricultural Research Service, examines rapid growth of hydrilla plants clogging the channel. ARS scientists are studying ways to use insects or fish to keep waterways free of aquatic weeds. Story on page 6. Photo: Tim McCabe. (0387X210-16)

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DEPARTMENTS

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Ridges Gain Favor

Corn Belt farmers are increasingly growing their corn and soybeans on raised seedbeds to save fuel, labor, and time.

Raised seedbeds also tend to dry and warm up faster than level ones, a marked advantage at planting time in the northern Corn Belt if soils are poorly drained.

Raised seedbeds are not a new idea, but today's farmers are combining them with minimum cultivation in a technique called ridge tillage. Special planters sweep a couple inches of topsoil off seedbeds and push it along with accompanying residue from the previous crop into furrows between rows.

Ridge tillage eliminates fall and spring plowing, leaving residue to protect the soil from erosion. It also reduces compaction because seedbeds never receive the weight of farm machinery. Wheel traffic is confined to the same furrows year after year.

This advantage, coupled with the shallow tillage on the ridgetops, is what interests Norman R. Fausey, a soil scientist with USDA's Agricultural Research Service at Ohio State University in Columbus. Fausey, a drainage expert, wants to see if ridge tillage will reestablish large, stable soil pores of the type that existed before more than two decades of tillage with heavy farm equipment crushed them.

Now in the fourth year of a northern Ohio study, Fausey and colleagues within the agency and at Ohio State have four test plots that are typical of compacted land in the Corn Belt. They have been used to grow corn or soybeans every year for 24 years. Years of fall plowing and spring tillage have destroyed large soil pores. So water has trouble soaking down to the perforated pipes placed a few feet below ground to drain soils. Instead, more water flows across the surface, eroding soil; and slow drainage delays planting.

To judge the effects of ridge tillage, Fausey irrigates each plot and then measures the rate at which water drains into devices placed at the edges of the field and at the outlets of the underground pipes.

After a few more seasons, a verdict should be in on how well the technique repairs the land.

In the meantime, more and more farmers are reaching their own verdicts: Ridge tillage has more than doubled in the Corn Belt since 1983, from 361,175 acres to 778,089 acres, according to the Conservation Technology Information Center in Fort Wayne, IN.—By **Don Comis,** ARS and **Betty Solomon,** ARS (retired). *Norman R. Fausey is in USDA-ARS Soil Drainage Research, 590 Woody Hayes Dr., Columbus, OH 43210.* ♦

Tracking Wasps With Rubidium

Insects within a species look alike, and that's often a problem even for scientists. It's especially a problem when they are trying to keep track of laboratory-reared beneficial wasps *(Anaphes obijentatus)* in the midst of alfalfa fields near Tucson, AZ.

There, the tiny, one-fiftieth-inch-long wasp mingles with the native population of the same species to destroy eggs laid by the lygus bug. Adult lygus bugs, about one quarter inch long, can extensively damage cotton, beans, alfalfa raised for seed, vegetables, fruits, and some nuts.

"If we just dumped laboratory reared insects into a field, we might never know what happened to them. To determine if our beneficial insect-release program is successful, we must know how far our insects move and how long they live," says entomologist Harry M. Graham at the Agricultural Research Service's Biological Control of Insects Laboratory.

One way to track the laboratory wasps is by rearing them on a rubidium-laced diet of lygus bug eggs. Later, when wasps are trapped at various places in the fields, an analysis for this metal indicates whether they are from the laboratory or are native.

ARS and University of California Riverside scientists developed the rubidium-tracking technique in 1972 and successfully used it on a number of insects. Entomologist Charles G. Jackson modified the technique for this first use with a beneficial insect that lays its eggs inside those of a pest insect. The developing wasp larvae eat away the insides of the lygus bug eggs.

Previously the only method of tracking egg-eating insects was to tag them with low-level radioactive material. This required careful handling and special permits.

The wasps can kill up to 60 percent of the lygus bug eggs in alfalfa grown for seed. However, many times, too few wasps are present and lygus bug populations soar out of control. "We would like to have extra wasps on hand to supplement native populations and thus avoid pesticide application," says Jackson.

"We hope by boosting the population of beneficial native insects, like this wasp, and by importing other predatory insects from foreign countries, we can stop the millions of dollars damage the lygus bug inflicts on crops each year," Graham says.—By **Dennis Senft,** ARS.

Harry M. Graham and Charles G. Jackson are at the USDA-ARS Biological Control of Insects Laboratory, 2000 East Allen Rd., Tucson, AZ 85719. ♦

Aluminum Replaces Lead in Sugar Test

Virtually all sugarbeet processors in this country have abandoned a lead-based test for sugar content in beets in favor of an aluminum test developed by an Agricultural Research Service scientist. Five years ago, the sugarbeet-processing industry relied exclusively on a test using lead.

Concern that some of this lead might eventually seep into water supplies prompted ARS plant physiologist Susan S. Martin to find a safe alternative. Her test uses small quantities of aluminum—a metal that

poses no risk to the environment—and produces accurate results. A plant that processes 400,000 tons of sugarbeets annually would use only 3 pounds of aluminum, eliminating the use of more than 125 pounds of lead.

Testing for sugar determines how much money each grower should be paid. Depending on grower skill, beet variety, and climatic conditions, sugar content can vary from 12 to 19 percent. Conceivably, growers shipping 2,000 tons of sugarbeets could actually have produced from 240 tons to 380 tons of sugar and received the same price if testing wasn't done.

Martin says that beet juice samples, like freshly cut apples, naturally turn brown because enzymes previously locked inside individual plant cells are free to react with other cell constituents in the presence of oxygen in the air. Like a hand breaking a light beam to prevent an elevator door from closing, this browning blocks a polarized light beam that is the basis for the sugar test and makes measurement impossible. Metals clear the samples for analysis.

Rather than modify testing equipment or attempt to develop an entirely new procedure, Martin theorized that another metal might substitute for the lead. After checking several other metals, Martin found that aluminum, in addition to being inexpensive and safe, was every bit as accurate as lead.

Martin is now working on a new procedure that would be metal-free. Scientists who are trying to breed better sugarbeets often need to make several measurements on the same juice sample. Both lead and aluminum, when used to determine sugar content, can taint or modify the sample so scientists can't determine, for example, other components that are important indicators of sugarbeet quality.—By **Dennis Senft,** ARS.

Susan S. Martin is in the USDA-ARS Sugarbeet Production Research Unit, Crops Research Laboratory, 1700 Center Ave., Fort Collins, CO 80526. ♦

Nitrogen-rich roots of Nitro alfalfa (right) are significantly larger than the roots of a conventional alfalfa variety. (Photo: Dave Hansen, U. of Minn. Agric. Exp. Stn.) (0487X309-30A)

Rebuilding Soil in a Year

A 1-year alfalfa promises to simplify good soil management and help hard-pressed farmers cut back on fertilizer costs.

The new variety, named Nitro, not only fixes almost twice as much home-grown nitrogen as ordinary varieties, but can also be planted as an annual in erosion-prone, row-crop rotations in the Snow Belt. That trait provides a soil-building option for grain and soybean growers reluctant to tie up land in alfalfa, typically for 3 or 4 years.

In tests, Nitro yielded three hay cuttings in a season and still left 94 pounds of nitrogen fixed from the atmosphere in the soil for succeeding crops. Its best competitor among traditional alfalfas left only 59 pounds. Moreover, Nitro also stored 30 pounds of "nonfixed" nitrogen taken up from the soil—banking a total of 124 pounds of nitrogen for the next year's crop.

Nitro is not a true annual but acts like one because it is a nondormant variety that usually can't survive a winter in the Snow Belt. When days get shorter and colder, conventional dormant alfalfas start storing sugar. But Nitro keeps growing up to 6 weeks longer, fixing and storing nitrogen in its large crowns and roots.

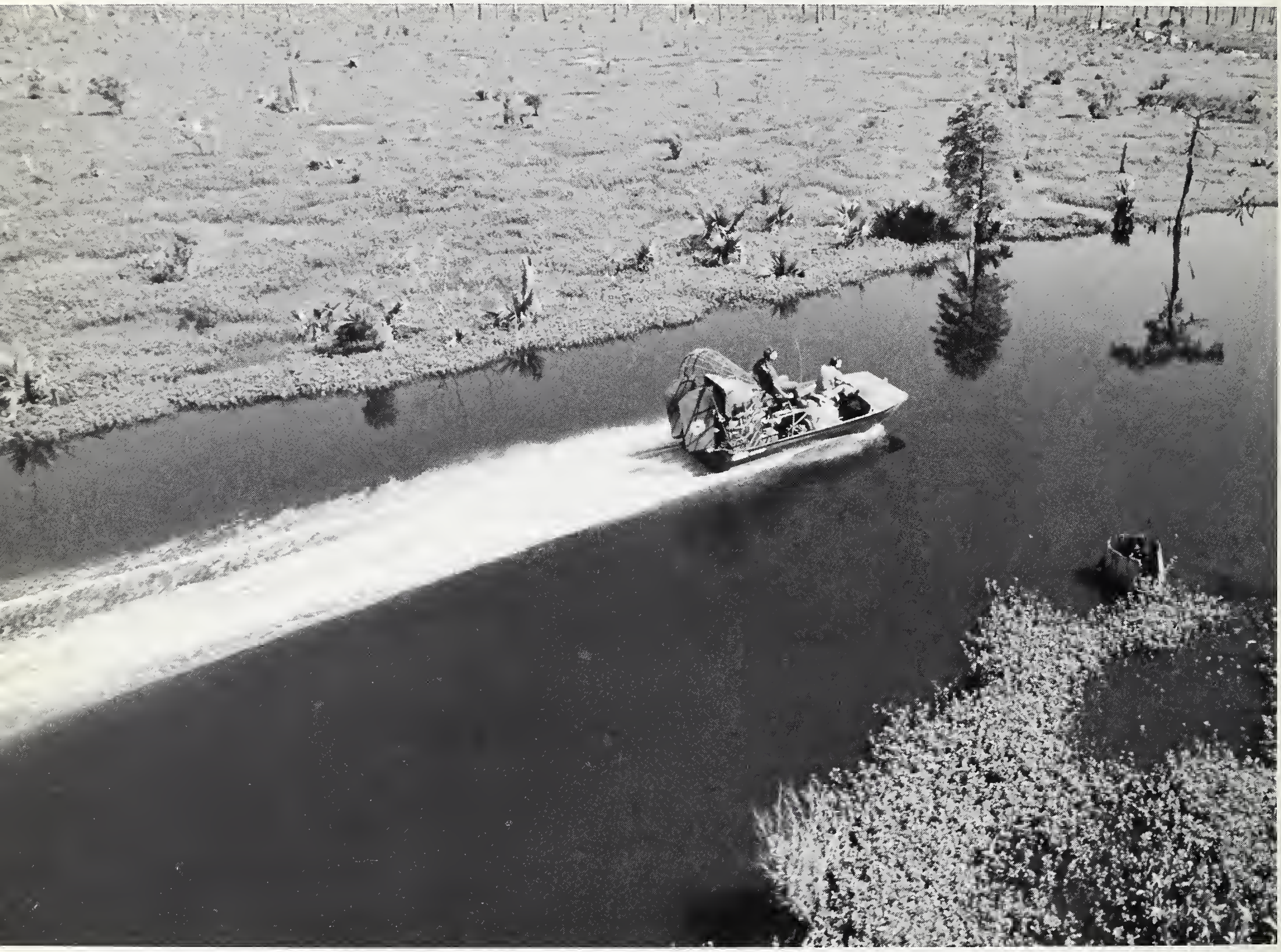
Nitro was developed by Donald K. Barnes, a plant geneticist, and Gary Heichel, a plant physiologist, both with the Agricultural Research Service, and Craig Sheaffer, a research agronomist with the University of Minnesota. They are based at St. Paul, MN.

Supplies of Nitro seed were sold out for the 1987 season, but adequate supplies are expected next year. ARS and the University of Minnesota have applied for ownership rights under the Plant Variety Protection Act. If granted, only certified seed of Nitro will be sold.

Nitro will serve as a genetic baseline for future nondormant alfalfa varieties. Barnes says several seed companies are now working on nondormant alfalfas that "will probably be even better." They should be available in 3 to 5 years, he says.—By **Russell Kaniuka,** ARS.

Donald K. Barnes and Gary Heichel are in USDA-ARS Plant Science Research, University of Minnesota, Borlaug Hall, 1991 Buford Hall Circle, St. Paul, MN 55108. ♦

Putting the Bite on Water Weeds



Bob Bjork

In an airboat tour of a waterway once clogged with alligatorweed, federal and Louisiana state officials find easy navigating thanks to the weed-hungry flea beetle *(Agasicles hygrophila)*. (0474X558-13a)

What acts like a rubber bathtub stopper but is green, smelly, massive, ever-expanding, and alive?

A healthy population of aquatic weeds, of course.

''A plant out of its native home grows prolifically because it has no insects, fish, or disease to control it and voila, you have a weed,'' says Ted D. Center at the ARS Aquatic Weed Management Laboratory in Fort Lauderdale, FL.

The ability of water weeds to keep reproducing clogs waterways with seemingly endless mats of stems and leaves. The resulting ''stopper'' entangles swimmers and is a real pain in the neck to people wanting to do a little weekend fishing. But more importantly, it prevents water commerce, chokes irrigation pumps, and interferes with hydroelectric operations.

Obviously, effective controls are a must.

Sometimes, Center says, the chemical and mechanical controls used on weeds don't work. Or if they do, their effects aren't lasting or using them costs too much.

So scientists have turned to another method called biological control. This alternative often ends up being more effective, cheaper, and more lasting. It also doesn't put chemicals in the water.

The Agricultural Research Service has set up laboratories in Albany and Davis, CA, and Gainesville and Fort Lauderdale, FL, to do biocontrol work on aquatic weeds.

In Florida, ARS scientists work with the University of Florida and the Army Corps of Engineers, which is interested in the research because it is charged with keeping waterways navigable.

Alligatorweed, originally from South America, was ARS's first aquatic biocontrol victim. About 20 years ago, scientists from the Albany lab went to

Bob Bjork

Above: In the war against alligatorweed, a tiny South American flea beetle *(Agasicles hygrophila)* has proved to be a hero since its introduction in 1972. (0474X552-1a)

Bob Bjork

Right: Heavy mats of alligatorweed in Louisiana plague fishermen. Photo on page 6 of the same waterway 2 years later shows effectiveness of *Agasicles*. (0872X1189-17)

Argentina to find insects that might eat the weed. The result: three insects hungry for nothing but alligatorweed, released between 1964 and 1971.

One, the alligatorweed flea beetle, has practically eliminated the weed in Florida. Another, a moth, helped the beetle bring it under control in the Mississippi Valley, and the third, a thrips, has done its small part in controlling alligatorweed along the banks of lakes and rivers.

Water hyacinth, which grows 3 feet tall and fills waterways in southeastern states, is getting the same kind of treatment. This weed received renewed attention in the 1970's when scientists realized the easy control they got with herbicides did not last.

So ARS scientists exploring in Argentina found *Neochetina eichhorniae*, and colleagues worked with local biologists (U.S. Army Corps of Engineers and Louisiana Wildlife and Fisheries Commission) to release this weevil in 1974. Since then, Louisiana waterways clogged with water hyacinth have dropped from 1.2 million acres to about 358,000. Scientists think *N. eichhorniae* prevents most annual regrowth after cold weather reduces infestations.

In Florida, the weevil and herbicides worked together to reduce weed-matted waterways from 100,000 acres in 1975 to about 15,000 now.

The weed, complete with an orchid-like lavender flower, was originally introduced in the 1800's, maybe from Venezuela. Spectators at the cotton exposition at the New Orleans World's Fair in 1884, charmed by the beautiful water flower, took home samples as souvenirs.

Spectators at the cotton exposition at the New Orleans World's Fair in 1884, charmed by water hyacinth's orchidlike lavender flower, took home samples as souvenirs.

"Those people probably put them in their pools as ornamentals and then, after the plants filled the pool, they thinned them by throwing some into the river," Center says.

Biological Controls Require Homework

Before any weed can be controlled by a biocontrol insect, the scientists must do their homework. They identify parts of the world where the weed is native and choose an area with climate most similar to the United States.

When they reach that area, they watch the weeds to pick the insects most hungrily eating the plants.

The winners are scooped up and put into a jar or plastic bag.

The insects, maybe as many as four different types, might be stuck in a researcher's suitcase.

"It's very interesting when we go through customs," says Gary Buckingham, entomologist at the Biological Pest Control Research Laboratory in Gainesville, FL. "Radiation could damage the insects, so we have permits allowing them to avoid the X-ray machines. But it still takes a lot of explaining to agents."

Tim McCabe

Hydrilla weevil *(Bagous affinis)* feeds on the plant's tubers. (1286X1369-18)

Once the insects enter the country, they might visit the Smithsonian's National Museum of Natural History in Washington, DC, not to be put on display but to be identified by scientists in the ARS Systematic Entomology Laboratory there. "We want to make absolutely sure we got the right insect," Buckingham says.

Then the insects undergo testing, in quarantine in the Gainesville lab, to make sure they don't have a fungus or protozoan that might wipe them out once released. All specimens with disease are disposed of, while healthy ones are selected and mated to create a healthy colony.

Buckingham also tests the insects on other plants to further verify they will eat only the targeted weed.

With all this done, insects chosen as biocontrol heroes will next be cleared through USDA's Animal and Plant Health Inspection Service and each affected state's agriculture department.

Those that pass move on to the Fort Lauderdale lab. There, Center will rear mass quantities of the insect and release them on a test site.

He then monitors them to see how they do. Hopefully, the insect starts clearing out the weed right away.

Hopefully.

Sometimes, There Are Problems.

Sometimes, as in the case of the alligatorweed flea beetle, the insect doesn't survive well in coastal climates. Then the moth that eats alligatorweed takes over. "Many times these insects complement each other this way," Center says.

Another problem is that sometimes the insect doesn't work fast enough for people wanting to fish, boat, or ship cargo through a waterway. In these cases, scientists often look to integrating the insect into programs that include chemicals or mechanical removal. In fact, Center, plant physiologist Thai Van, and their research leader, Kerry Steward, are looking at chemical growth retardants for water hyacinth that might help *N. eichhorniae* in controlling this weed.

Insects that don't spread out from the point of release offer yet another problem. For example, the alligatorweed thrips, a very slow-moving insect, gives good control, but only at the exact point where it is released. It can't fly, so it really has no way to infest other sites. For thrips control at additional sites, scientists have to release more insects, a time-consuming and expensive proposition.

Still another complication could come if native animals or insects find the newcomer tasty. Scientists think the water hyacinth moth offers only partial control because native insects and disease are doing it in.

Biological controls sometimes don't work fast enough for people wanting to fish, boat, or ship cargo through a waterway.

Center hopes that won't happen to *Bagous affinis*, a weevil to be released in Lake Tohopekaliga, FL, this spring. There, it will do battle against hydrilla—infamous pest of waterways in southeastern states, Texas, and California. The insect, brought from India, concentrates its efforts on burrowing into, and feeding on, the weed's underground tubers.

"This insect will work only if the water is drained, which includes water bodies that periodically go dry on their own and those that are drawn down artificially. Drawing down the water is sometimes done anyway in an effort to dry weeds out, thereby killing them.

The same trip on which *B. affinis* was recruited also netted *Hydrellia pak-*

istanae, a fly whose larvae feed on hydrilla leaves (name similarity is coincidental).

The Florida scientists had hoped to use *B. affinis* in California, where hydrilla is found in canals that can be drawn down. But scientists in California are now using a bigger weed eater that does just fine in water: grass carp.

These fish feed voraciously on hydrilla and other aquatic weeds. At some stages of its life, a carp can eat two to three times its weight in hydrilla every day, says Lars W.J. Anderson of the Aquatic Weeds Control Laboratory, Davis, CA. "That means you could have a 5-pound carp eating 10 or 15 pounds of hydrilla every day. That's an incredible amount."

Anderson is part of an interagency team that has brought these artificially sterilized fish into the state for stocking in hydrilla-clogged canals of southern

"A 5-pound carp could eat 10 or 15 pounds of hydrilla every day. That's an incredible amount."

Lars W.J. Anderson, ARS plant phisiologist, Davis, CA.

California's Imperial Irrigation District.

Preliminary results show that in 95 percent of the canal sections where the fish were stocked, they ate all of the hydrilla—except the roots, underground stems, and the bulblike tubers buried in the muddy bottom of the canals. The next critical step will be to find out how well the fish controls regrowth from stems and tubers.

The experiment involves the Animal and Plant Health Inspection Service, the U.S. Department of the Interior's Bureau of Reclamation, two State of California Departments (Fish and Game and Food and Agriculture), the Imperial and Coachella Valley Irrigation Districts, and Imperial County.

Work is proceeding cautiously because of concern that some carp might accidentally escape or breed successfully. Some people fear that the carp could possibly outcompete and drive away other species that live in the

Tim McCabe

The grass carp is now under study by ARS scientists to determine its effect on waterways obstructed by hydrilla, sago pondweed, Eurasian watermilfoil, and elodea. (0387X217-16)

canals, such as channel catfish, largemouth bass, flathead catfish, and bluegill.

"One reason the Imperial District is a good site for this experiment is that the only downstream escape route for the carp would be into the Salton Sea, where the salinity is so high that the carp couldn't survive," says Anderson.

Some 400 miles of the Imperial District's 1,600 miles of canal were infested with hydrilla before the carp were brought in, says Randall Stocker, the irrigation district's lead scientist for aquatic plant control. Now, only the roots and tubers remain.

In the past, the district could afford to treat only what he describes as "the worst spots" because chemicals or mechanical methods, such as scooping plants and the mud they're anchored in


Tim McCabe

Technicians Robert Pine (left) and Craig Ksander (center) assist Lars Anderson in monitoring the growth of Eurasian watermilfoil, a weed that chokes waterways in northern California. (0387X213-23)

from the canal bottoms, cost from $400 to $1,000 per acre. The District usually spends $200,000 to $300,000 each year on this type of weed control.

In contrast, the fish cost the District only $100 per acre, at $5 or so per carp, Stocker says. Last year, only 1 year after the carp were stocked, the District spent just $50,000 on chemical and mechanical control, and has since stopped using chemicals entirely.

Stocker expects the carp to be good for at least 5 years of canal weed mowing. After that, they may slow down. Explains Jim Malone of Malone and Sons, the Arkansas company that provided the sterile carp, "When the fish get fat and middle-aged, they may not eat as much."

Statewide, efforts to control hydrilla cost Californians $13.5 million over a recent 8-year period.

Although Stocker estimates that the Imperial Irrigation District was probably the first organization in the United States to use carp on such a large scale (about 60,000 fish have been stocked so far), at least 16 other states allow the sterile fish to be brought in for research or for control of aquatic weeds.

Grass carp are also used in Europe, Russia, and especially in China where for hundreds of years they have helped keep water weeds in check.

In the California experiment, the carp seem to be succeeding famously where another type had failed several years ago.

The unsuccessful carp was the hybrid offspring of grass carp and bighead carp. "It was sterile—which was important—but it didn't eat worth a darn," Anderson says. "It was a lack of vigor—a problem that sometimes happens when you try hybridization. In that case, the offspring didn't eat as much or didn't grow as fast as the grass carp parent."

The new carp, in contrast, isn't a hybrid; it's simply the natural offspring of grass carp parents. It's produced from a fertilized egg subjected to either a heat-shock or pressure treatment resulting in a fish that has a third, extra set of chromosomes.

While normal or diploid carp have two sets of chromosomes (one set from each parent) and so can reproduce, the triploid offspring can't.

Anderson's focus right now is on seeing if the triploid carp can be put to work in canals of northern California—where the water is colder and other plants such as sago pondweed, Eurasian watermilfoil, and elodea (a hydrilla look-alike) are more of a problem than hydrilla.

Be it California, Florida, or Louisiana—using fish from Arkansas or insects from India and South America or residue-free herbicides—ARS scientists keep trying to pull the weedy plug in the nation's waterways.—By **Jessica Morrison** and **Marcia Wood,** ARS.

Ted D. Center is at the USDA-ARS Aquatic Weed Research Laboratory, 3205 College Ave., Fort Lauderdale, FL 33315. Gary Buckingham is at the USDA-ARS Biological Control Laboratory, P.O. Box 1269, Gainesville, FL 32602. Lars W.J. Anderson is in USDA-ARS Aquatic Weed Control Research, University of California, Davis, CA 95616. ♦

When Biological Controls Don't Work

Using insects and fish as aquatic weed-eaters is still the exception in a world where chemicals and mechanical removal have often been the most effective ways to control weeds.

Where that's true, ARS weed fighters around the country look for the best combination of methods and the lowest effective amounts of the safest chemicals. One recent example in the Pacific Northwest involves reed canarygrass blocking irrigation canals.

When the grass grows in canals, its fine roots collect silt and eventually builds a natural dam or berm strong enough to drive a tractor across. If uncontrolled, berms can become 6 feet wide and 7 feet high in only 5 years, causing irrigation water losses totaling millions of dollars a year.

ARS agronomist Richard D. Comes, at the Irrigated Agriculture Research and Extension Center in Prosser, WA, found what appeared to be the perfect solution: Zap the berms with glyphosate, a herbicide that leaves no residues; pull out the dead berm with a backhoe or other mechanical equipment; and reseed the area with creeping red fescue, a type of short grass that prevents erosion.

But within 2 to 4 years after berms were sprayed and removed, canarygrass resprouted all but eliminating the fescue, and could have formed new berms.

"We had to go back to the drawing board," says Comes. This time, he and his colleagues found that the reed canarygrass can be controlled by spraying it with glyphosate every other year in the spring. Very little herbicide is required. Only 2 to 4 pounds of glyphosate will control reed canarygrass along 6 miles of one bank or 3 miles of both banks, he says.—By **Howard Sherman,** ARS.

Richard D. Comes is at the USDA-ARS Irrigated Agriculture Research and Extension Center, P.O. Box 30, Prosser, WA 99350. ♦

The Arboretum Is Blossoming Out All Over

The family sightseeing in Washington, DC, runs down a list of places to visit: the Smithsonian, the White House, the Lincoln Memorial... and they may miss one of the Capital's real treasure houses—the U.S. National Arboretum.

A kind of working laboratory for living plants, the Arboretum is off the beaten path for many tourists, a few miles east of the U.S. Capitol and the Washington Monument. Even so, half a million visitors a year wander through its 444 acres of blooming cherries, crabapples, and azaleas in April and waterlilies, hibiscus, and crapemyrtles in August. And in the winter, they can enjoy the hollies and evergreens or the National Bonsai Garden which is open year round.

But many visitors may not realize that the nearly 60-year-old Arboretum is more than a display center.

"Exploration by Arboretum scientists and research done on our grounds allow us to introduce truly beautiful landscape plants for American gardens," says research leader Alden M. Townsend.

Beauty isn't the only goal of exploration and research: "We want plants that have an inherent vigor so that we don't need to baby them—we want superplants!" he says.

The characteristics of a superplant? Resistance to stresses like de-icing salts and pollution (both common to urban areas), insects, diseases, drought, and low temperatures.

Disease resistance—specifically, resistance to mildew—is what John L. Creech found in Japan in the 1950's. He traveled there to find superplants that could offer new landscape trees and shrubs. He brought back a new species of crapemyrtle that is, it turns out, resistant to mildew. After years of research and selection at the Arboretum, a landscape plant that was almost completely destroyed in the United States by mildew was revived.

"Exploration and research by Arboretum scientists allow us to introduce truly beautiful landscape plants for American gardens."

Alden M. Townsend, research leader at the U.S. National Arboretum

Tim McCabe

Thousands of visitors tour the National Arboretum annually. One popular attraction is the aquatic garden around the Administration Building. (0786X773-6)

On finding a plant that looks promising, an explorer documents it—which includes taking notes that pinpoint exactly where it came from—and prepares a dried specimen of it. The specimen and documentation together are called a herbarium specimen, to be stored for reference for years to come with the more than 500,000 already at the Arboretum.

The specimens help scientists document and identify plants, important work called taxonomy.

"Taxonomy is vital to the nursery industry because consumers need to be sure they're getting what they think they are," Townsend says.

Explorers also bring plant parts—seeds, cuttings (branches), roots, underground stems, or all four. "We

Tim McCabe

Botanist Theodore Dudley (right) and plant geneticist Alden Townsend review specimens of woody plants collected by Dudley during an expedition to China in 1980. (0387X185-6)


Tim McCabe

Botanist Roland Jefferson (left) and horticulturist Donald Egolf examine cherry tree seedlings grown from seeds collected by Jefferson in Taiwan. (0387X195-32)

bring back as much plant material as we can so that we're sure to have the treasured genes to work with,'' says botanist and plant explorer Theodore R. Dudley.

The new species is planted at the Arboretum and sent out to other arboretums, botanical gardens, and nurseries nationwide. ''We send it wherever we think it might have a chance of surviving—and even where we think its chances are marginal—because the plant's success in the District of Columbia isn't the only important thing,'' Townsend says. ''We have to know how it will do nationally—we are the *National* Arboretum.''

At the Arboretum itself, any new plant is subjected to a number of tortures. Short of being torn limb from limb, it might undergo every possible plant peril—air pollution, insect attack, harsh weather, or lethal diseases.

A plant that passes local and national tests might be propagated as is, with scientists selecting the best of the bunch for eventual release. Or, it could be crossbred with plants already here to yield a hybrid, which would also undergo selection. In selection, scientists choose the most resistant, hardy, and attractive of experimental plants and multiply them.

Then they repeat the process, until eventually they have a plant with excellent genes—genes for beauty, hardiness, and stress tolerance.

Nationwide cooperation resulted in the Arboretum's two new magnolias, Spectrum and Galaxy.

Both magnolias have flowers that ''look like little pink spaceships have landed all over a great big upright tree,'' says director Henry M. Cathey. ''And they have a gray, majestic-looking bark that will add a touch of elegance to urban landscapes.''

But there is one important difference between the two magnolia varieties: Spectrum is best suited to southern states, while Galaxy survives as far north as upper New Jersey—unique since most magnolias only make it in southern climates.

''Our cooperating gardens and nurseries help us create beautiful landscapes for all of North America,'' Cathey says. The two magnolias were released in 1986.

Sometimes, exploration and research can lead to unexpected, but pleasant, surprises. The mildew-resistant crapemyrtles brought from Japan by Creech also ended up having a cinnamon-colored bark instead of the light grayish-tan bark available then.

But the flowers of the Japanese crapemyrtle are all white, while domestic varieties come in many different beautiful colors. At the Arboretum, the new and old species were crossed and the best progeny selected. The result: Eleven new, mildew-resistant varieties—with different flower colors and bark colors that range from white and light brown to a dark brown/burgundy color. All were released to industry for sale to consumers between 1979 and 1987.

Of course, ''release'' doesn't mean the scientists completely let go of any plant. They always keep specimens—of both crossbred and original plants—in case further breeding is desirable.

''It is crucial that we maintain genetic potential for possible use later; the Arboretum serves as a germplasm repository—a sort of seed bank,'' Townsend says.

''Every bit of the material here, with only a few exceptions, is here for research purposes,'' he says.—By **Jessica Morrison,** ARS.

Alden M. Townsend is at the USDA-ARS National Arboretum, 3501 New York Ave., NE, Washington, DC 20002. ♦

The Pinking of America

The latest U.S. National Arboretum exploration has yielded budwood from two double-flowering varieties of cherry trees that bear blossoms of 25 to 50 petals. Most of the ornamental cherry trees now grown in this country are single flowering, bearing five-petal blossoms.

One double-flowering selection from Japan, *Prunus sargentii,* survives winters down to -31° F and resists most insects. Its light-pink blooms appear in mid to late March.

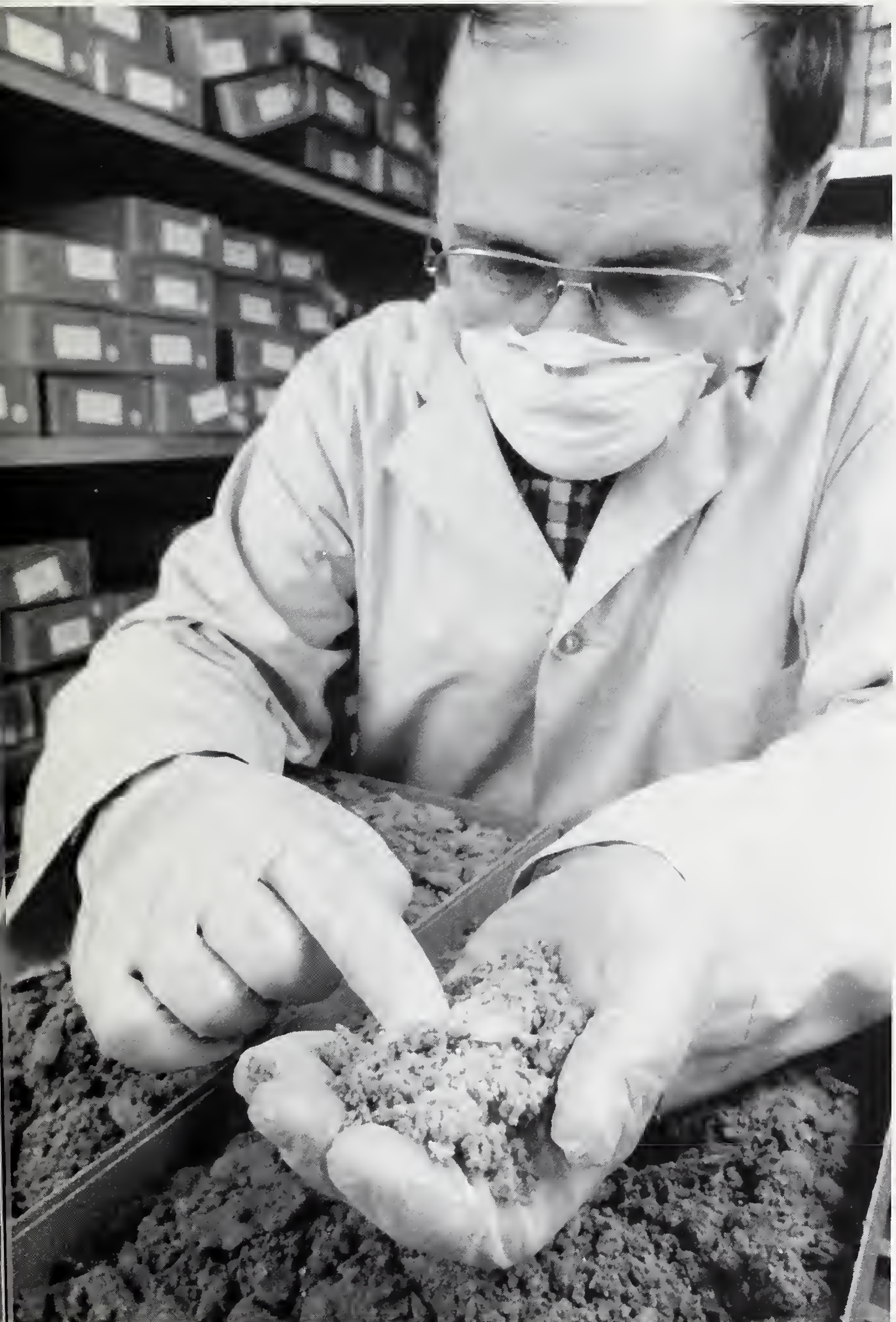
The other, *Prunus campanulata,* is a warm-weather cherry from Taiwan suited to southern parts of the United States. It blooms in winter and has large, deep-pink blossoms.

''Budwood for these two cherries is now in quarantine near Washington, being tested for disease,'' says Roland M. Jefferson, a botanist at the Arboretum. The quarantine period could last for up to 6 years.

Jefferson spent 6 months in 1986 in Japan, Korea, and Taiwan looking for seeds to improve the quality and extend the growing range of the oriental flowering cherry trees in this country.

Some of the 200,000 seeds he brought back have been used to produce seedlings in the Arboretum greenhouses. These seedlings—which are not subject to quarantine—could be used to develop superior types of fruiting cherries as well as flowering ones.—By **Doris Sanchez,** ARS. ♦

Second Generation Sterility



Bob Bjork

Gypsy moth egg masses in cold storage are examined by entomologist John Tanner, supervisor of rearing and egg production at the APHIS Cape Cod facility. An estimated 1 billion eggs in this room will be placed in forests this spring in North Carolina, Ohio, Vermont, and Washington. (0387X226-30A)

USDA scientists are playing matchmaker for female gypsy moths infesting the Northeast and spots in other parts of the country. The scientists have lined up 200 million willing suitors and hope that each female moth in targeted forests finds one to suit her fancy. The males singled out for this lonely hearts club have one special trait in common: sterility.

Garbed in gray or cream-colored scales, gypsy moth adults escape the attention of most observers. But their larval youngsters have voracious appetites that can turn a summer forest into skeletons of leaf-stripped trees. A hardwood tree usually dies after two or three of these defoliations; an evergreen may succumb after a single stripping.

Once they have turned the forest canopy into a wriggling mass of larvae, the invaders spin cocoons and spend 2 quiet weeks changing from caterpillar to moth. Then adult gypsy moths emerge for the sole function of reproduction. In fact, the adults lack mouthparts or digestive systems.

"This isn't the first time scientists have used sterile males to dupe female insect pests into laying eggs that never hatch."

Victor C. Mastro, APHIS entomologist

The scientists hope that wild females, flanked by hundreds of sterile suitors, will choose one of them. Then, although the females lay their eggs before dying, the eggs will fail to hatch. This scheme protects the forests without damaging the environment.

"This isn't the first time scientists have used sterile males to dupe female insect pests into laying eggs that never hatch," says Victor C. Mastro, entomologist with the Animal and Plant Health Inspection Service, the USDA agency responsible for implementing the new program. The sterile male scheme, the brainchild of Edward F. Knipling, former director of entomology research for USDA's Agricultural Research Serv-

(continued from page 13)

ice, has successfully eradicated or controlled other insects such as the screwworm and the Mexican fruit fly. However, the new program goes an important step beyond past projects.

Formerly, male adults received a sterilizing dose of irradiation and were released into the wild to thwart the reproductive efforts of females. The new plan, developed by APHIS, lowers the dose of irradiation—resulting in fertility for the irradiated male but sterility for his offspring. Then, APHIS mates the irradiated males with normal laboratory females and harvests the eggs to store and distribute in infested areas. Larvae hatching from these eggs mature and mate normally, coinciding with the lifecycle of the native population—with the vital difference of being sterile.

"Synchronous development of insects is critical," explains Charles P. Schwalbe, Director of the APHIS Methods Development Center at Otis Air National Guard Base, MA. "Adults emerge and almost immediately begin mating; if the steriles aren't released right on time, they're wasted.

In addition to hatching at the same time as the native population, egg releases offer other benefits. Less fragile than adults, eggs are easier to handle and transport. Perhaps the biggest benefit of releasing eggs is that unlike adults, eggs can be stored for months, increasing production capacity by as much as 1,000 times. Even allowing for high larval mortality, this still provides a tenfold improvement over sterile moth releases.

"Nature helps us out here," says Mastro. Female moths lay eggs from mid-June to late July, but they hatch together the following spring. "By tinkering with the temperature, APHIS can simulate this natural egg storage system."

In order to swamp the native population and ensure that females mate with sterile moths, APHIS tries to achieve a ratio of 40 to 50 sterile males to each wild, fertile one. This demands a huge production effort, greatly aided by stockpiling eggs.

But rearing and releasing billions of eggs that develop into adults that mate normally but lack fertility is not without

Above: A female gypsy moth lays her eggs on the bark of a tree. Weak from being unable to eat, she cannot fly and will soon die. (BN-25394)

Above right: Gypsy moth caterpillar on a twig. (0772X955-16A)

Right: Technician Alida Pellegrini-Toole and entomologist Vic Mastro treat gypsy moth pupae with radiation. Male moths emerging from irradiated pupae are to be mated to normal females. Eggs from these matings will develop into sterile males which interfere with gypsy moth reproduction. (0387X224-29)

Bob Bjork

its complications. To implement the program, two other groups of USDA scientists—as well as many state and university researchers—are collaborating with APHIS. The Agricultural Research Service and the Forest Service have both made invaluable contributions.

The expertise of ARS scientists helped to make mass-rearing a reality. Developing a stable, balanced, and inexpensive diet to feed mounds of immature gypsy moths was the special contribution of ARS entomologist Robert Bell. Mass-rearing demanded a diet that could be dropped in a container with the eggs and wouldn't deteriorate during the 33 days of larval development. "The problem was made trickier by the fact that the newly hatched larvae need a tender-textured diet, like the newly emerged leaves on April trees," says Bell. "In the older stages, how-

Larry Rana

Completely denuded trees in mid-August are proof of the gypsy moth caterpillar's voracious appetite. (0770C682-16)

ever, larvae thrive on a tougher-textured material.

Bell rose to this challenge by developing a wheat-germ-based diet that loses water, becoming more coarse with time and meeting the caterpillars' changing tastes. In so doing, Bell slashed the cost of diet from $1.60 per liter to around 35 cents, making eradication through sterile moths more affordable.

Once scientists could rear the needed number of insects, the Forest Service and APHIS delved into how the irradiated insect behaved in the field. "A larva may look perfectly normal in the laboratory," says Forest Service entomologist Thomas M. ODell, "but its survival can depend on correct behavior in the wild." If, for example, the larvae eat during the day, instead of feeding at night like the native insects, birds and other enemies will eat the laboratory insects before they can mate.

Attracting some of these natural enemies is a side benefit of the sterile releases, notes ODell. Parasites—wasps and flies that attack gypsy moth larvae—are attracted by the sudden jump in food supply. The parasite populations build up and prey upon the pests, helping to control the infestation. With luck, the high level of gypsy moth enemies will continue to the following season and prey on the few remaining moths, delivering the death blow to the pest. The Forest Service is continuing to cooperate with APHIS to examine the behavioral aspects of the released insects as well as parasite population dynamics.

The new swarm of hungry gypsy moths released by USDA may attract parasites and predators, but it's unlikely to grab any human attention, according to Schwalbe. Although the releases increase the pest population initially, the levels are still too low to cause noticeable damage. "Sterile males are released only in isolated outbreaks with low pest populations; we wouldn't use the technique in areas where it would cause more harm than good," he says.

Gypsy moth control has not been the success story of the century. Beginning with their escape from a Massachusetts laboratory in 1869, the moths have exhibited a stubborn ability to spread their U.S. range despite continuing attempts at control. The gypsy moth larvae eats over 500 species of trees and shrubs. American oaks and alders are especially to their liking.

Freed of the diseases and predators which kept them from being a serious problem in Europe or Asia, gypsy moths in New England became like a community of mice without cats. Despite intense efforts involving surveying, quarantines, and insecticides, gypsy moths now infest all states east of Ohio and north of Virginia.

Outbreaks may leapfrog across states because female moths often lay their eggs on outdoor furniture, equipment, and vehicles. Once transported, stowaway pests begin new infestations.

The sterile insect program has proven especially effective in these isolated areas, with particularly noteworthy successes in Washington and Ohio. "Isolated infestations are like islands that can be fairly well studied," says ODell.

Scientists stress that other control efforts will continue, and that the sterile insect program isn't expected to be a panacea. They do, however, expect the new egg release program to give them an improved and environmentally sound way to grapple with the gypsy moth invasion.—By **Anita Brown,** APHIS.

Victor C. Mastro and Charles P. Schwalbe are at the USDA-APHIS Otis Methods Development Center, Bldg. 1398, Otis ANGB, MA 02542. Thomas M. ODell is at the USDA-FS Northeastern Forest Experiment Station, 51 Mill Pond Rd., Hamden, CT 06514. Robert A. Bell is in the USDA-ARS Insect Reproduction Laboratory, Room 214, Bldg. 309, BARC-West, Beltsville, MD 20705. ♦

How You Can Help

Public cooperation is vital in preventing new gypsy moth outbreaks. APHIS publication #1329, "Don't Move Gypsy Moth," describes how to detect hitchhiking pests. Copies of the free pamphlet are available by writing to APHIS Distribution Service, Room G187, 6505 Belcrest Rd., Hyattsville, MD 20782. ♦

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PATENTS

Starving Witchweed

The cost of inducing premature germination of witchweed seeds may be brought down by this improved way to make intermediate compounds in the preparation of strigol, a natural germination stimulant.

Scientists think the parasitic witchweed *(Striga asiatica)* normally sprouts in response to chemicals emitted by plants it lives off of, primarily corn, rice, sugarcane, and sorghum.

Natural sprouting is timed to allow the weeds to arrive only when the crops are growing.

Strigol, which was originally isolated from compounds emitted by cotton plant roots, can be used to give the signal so early that the weed starves to death before the crops grow.

But current methods for producing strigol involve numerous steps and costly ingredients, making it commercially impractical.

The new approach uses inexpensive starting materials and reagents and is suitable for large-scale production. Some of the compounds prepared in this approach show significant effects on another weed—branched broomrape *(Orobanche ramosa).*

At present, the commercial potential of this process is unknown, but there have been some inquiries from industry, especially from abroad. Witchweed is a major problem in Asia and Africa.

For technical information, contact Oliver D. Dailey, Jr., USDA-ARS Crop Protection Chemistry Research, P.O. Box 19687, New Orleans, LA 70179. *Patent Application Serial No. 814,944, "Process for Preparing Seed Germinating Stimulants."* ♦

Better Soybean Growth?

Soybean plants may make more nitrogen and grow more roots when infected with a variant bacterial strain.

This strain is a tan-colored variant of the normally colorless *Rhizobium* strain L-259, which is commonly applied by farmers in a mixture with other strains to enhance plant growth and nitrogen fixation. When inoculated with the variant strain, lab-grown soybean plants formed more and larger nitrogen-fixing nodules on the roots and a bigger root system.

Further investigation is needed to determine if this advantage will be seen on the farm as well.

For technical information, contact Tsuneo Kaneshiro, USDA-ARS Northern Research Center, 1815 North University St., Peoria, IL 61604. *Patent Application Serial No. 06/891,939, "Enhancement of Nitrogen-Fixation With Rhizobial Tan Variants."* ♦

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